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# Distal humeral septic non-union treated with debridement and vascularized fibular transfer: case report and review of the literature

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**Abstract.** **Clinical management of a septic non-union of the distal humerus is challenging and is complicated by the diversity of potential treatments which are variably successful. We report a novel and very successful treatment of a 58-year-old man presenting an infected non-union of the right distal humerus, secondary to a closed fracture initially treated with two anatomic plates. After hardware removal, a two-stage reconstruction was performed. Bone and soft-tissue debridement was performed, followed by vascularized fibular transfer and free iliac bone crest chips fixed with plates and screws. Consolidation was achieved within three months, and a very good elbow function was presented two years thereafter. This technique shows great promise for improved management of large segmental infected bone defects of complete articular distal humeral fractures, above many currently recognized treatments.**

Key Words
Fractures, Non-union, Humeral fractures, Bone diseases, Infectious, Fibular graft, External fixator.

## Introduction

The specific nature of the fracture pattern restricts treatment options for fractures of the distal humerus[1,2]. Most treatment options are complex, time-consuming, and may result in non-union in up to 10% of cases[3]. Management of non-unions is especially problematic due to factors including, but not limited to, infection, massive bone loss, and complications from previous surgical interventions[4-6]. Bone atrophy and soft tissue damage are frequently accentuated due to infections typically necessitating radical soft tissue and bone-debridement[3]. Occasionally, elbow arthrodesis may be the only effective treatment, but is challenging in the face of massive bone loss, and resultant suppression of joint mobility[7]. Alternative treatment may include total elbow arthroplasty or nonvascular bone grafts; however, these options are accompanied by significant risks of infection[8].

A vascularized bone transfer, such as interposition arthroplasty, has been proposed and described as an alternative to prosthetic replacement in young patients presenting elbow arthritis and/or massive articular defects[5,9,10]. Successful management of these highly complex situations necessitates multidisciplinary collaboration[11].

In response, we report the successful treatment of a patient presenting septic non-union and bone loss of the distal humerus, by reconstruction with vascular fibular graft (VFG).

## Case Report

### History

A 58-year-old male sustained a close distal humeral fracture of the right elbow (dominant side), classified as an AO/OTA type 13C2 fracture[12] (Figure 1 A-B). Initial treatment of internal fixation with two anatomic plates in acute failed to achieve bone fusion resulting in a non-union (Figure 1 C-D). Five-months post-operatively, hardware was removed; however, an infection was diagnosed (*Staphylococcus Hominis ssp Hominis*) and necessitated intravenous antibiotic treatment for three months.

Nine months post-operatively, the patient was referred to our surgical offices for further investigation and management.



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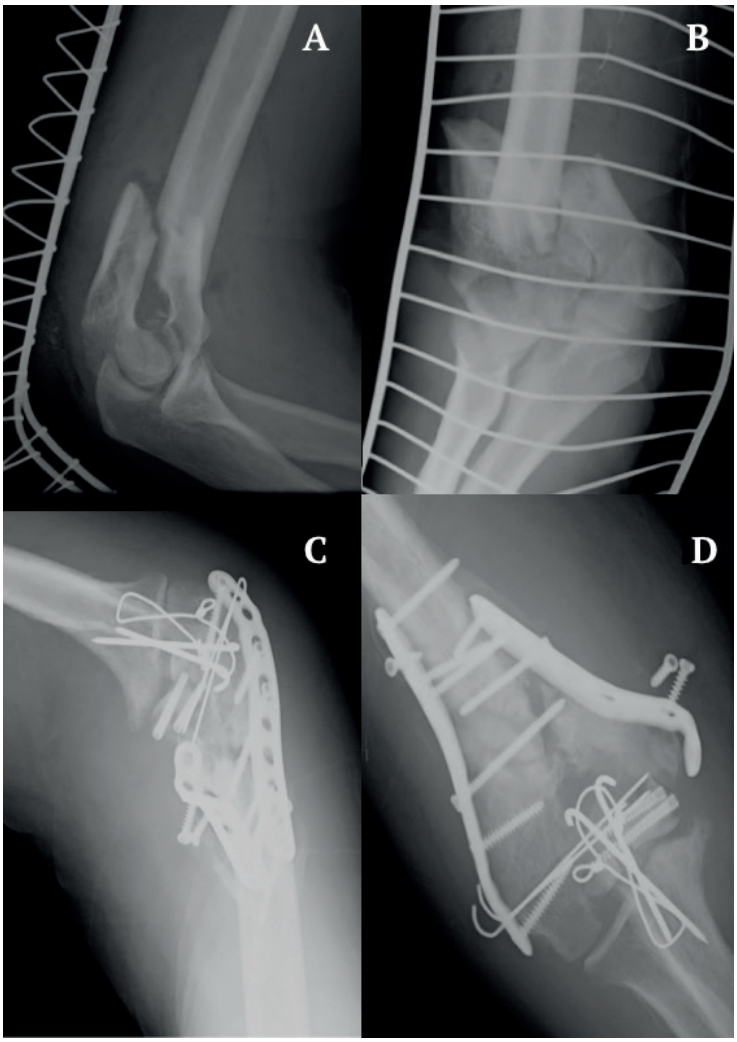


**Figure 1.** Emergency antero-posterior (**A**) and lateral (**B**) radiographs of the right elbow showing an AO/OTA type 13C2 distal humeral fracture. Antero-posterior (**C**) and lateral (**D**) radiographs of the right elbow five months after surgery.

Initial physical examination revealed signs of infection of the elbow's soft tissues, including: pain in active and passive motion, soft tissue oedema, redness, significant reduction of active and passive motion, and preternatural mobility at the non-union site accompanied by pain. Laboratory investigations identified a C-reactive protein (CRP) of 1.94 mg/dl and erythrocyte sedimentation rate (ESR) of 26 mm/h.

X-rays revealed a distal humerus non-union with heavy articular damage, massive bone defect, and radiological indications of osteomyelitis (Figure 2A-B). A computerized tomography (CT) scan revealed articular damage with almost complete loss of trochlear surface accompanied by a massive bone defect on the medial column side. Magnetic resonance imaging (MRI) showed important soft tissue involvement around the non-union site, and abundant newly formed tissue between bone segments, as well as bone oedema (Figure 2C).

### *Surgical Procedures*

We conducted surgical treatment in two phases. Phase 1 included substantial debridement of infected soft tissue, and resection of pathological bone and implantation of a cement spacer (impregnated with Gentamicin and Clindamycin) through a posterior transolecranon approach. A hinged elbow external fixator (Orthofix Srl, Verona, Italy) was installed to stabilize the elbow and control its range of motion which improved, in the absence of pain, one month thereafter (Figure 3).

Cultures of bone and soft tissue biopsies collected during surgery were negative.

Three weeks after surgery, the patient developed redness and seropurulent drainage from the pin tract. Pin site drainage was collected

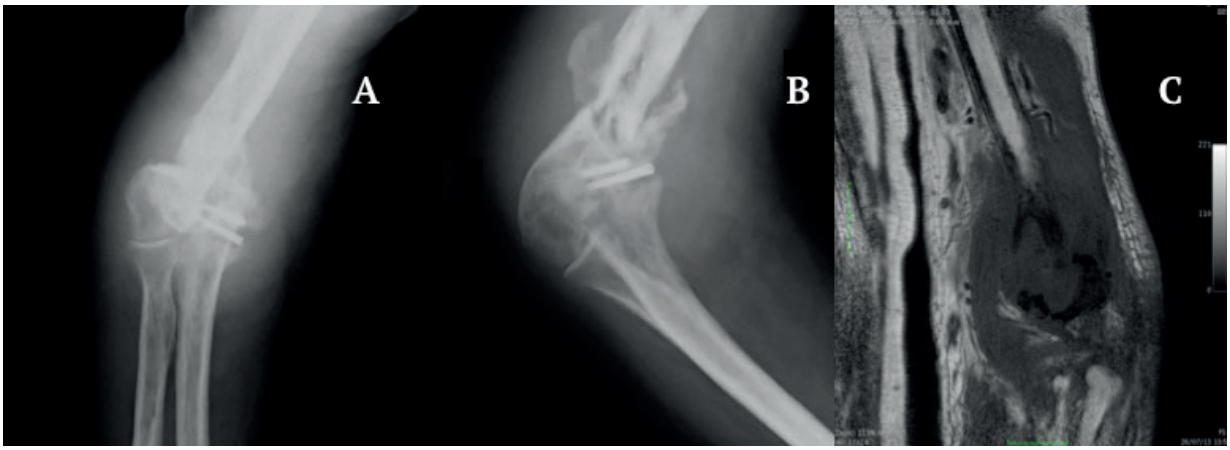


**Figure 2.** Antero-posterior (**A**) and lateral (**B**) radiographs of the right elbow nine months after surgery. Elbow's MRI (C) at 1 year after first treatment.

for culture. *Escherichia coli* was isolated and, according to the infectivologist indication, oral treatment with sulfamethoxazole-trimethoprim (180 mg/800 mg daily) for 14 days was prescribed. Because of poor clinical and biological response, antibiotic was changed in order to extend the spectrum of activity and to eradicate the infection. The patient started a more aggressive i.v. therapy with ertapenem + teicoplanin (1 g and 800 mg daily, respectively) for 14 days. After this treatment, the patient had no clinical evidence of infection, the levels of C-reactive protein (CRP) were 3.4 mg/l, while the erythrocyte sedimentation rate (ESR) was 17 mm/h.

Before Phase 2 of surgery, the patient was examined by $^{111}$In-labeled leukocyte scintigraphy (negative for infection) and an angiographic evaluation of the right upper-limb in order to study humeral perfusion.

Phase 2 (6 months) included reconstructive surgery with contralateral vascularized fibular transfer and free iliac bone crest chips accompanied by reparative surgery of the residual medial collateral ligament. A posterior incision incorporating prior incisions was used. After the identification and protection of the ulnar nerve, a chevron-shaped olecranon osteotomy was used to expose the distal end of the humerus. Fibrous tissues, cement spacer, and devitalized bone were removed to allow space for the bone reconstruction.

Cultures of bone and soft tissue biopsies collected during surgery presented no infections.

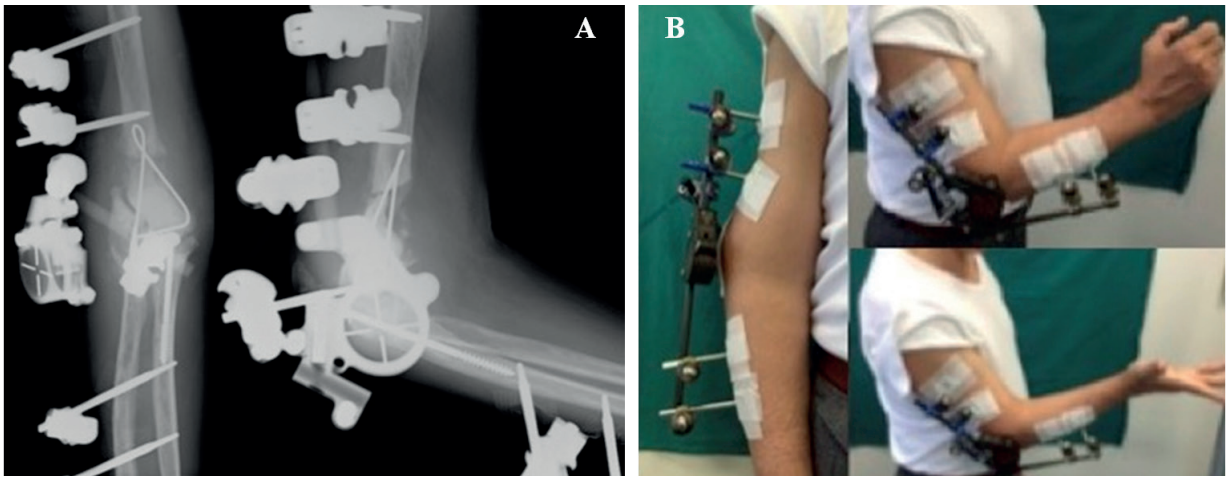


**Figure 3.** Elbow's X-rays after debridement and stabilisation with a hinged elbow external fixator (**A**). Clinical condition after debridement (**B**). Extension 40°; flexion 80°; pronation 45°; supination 10°.

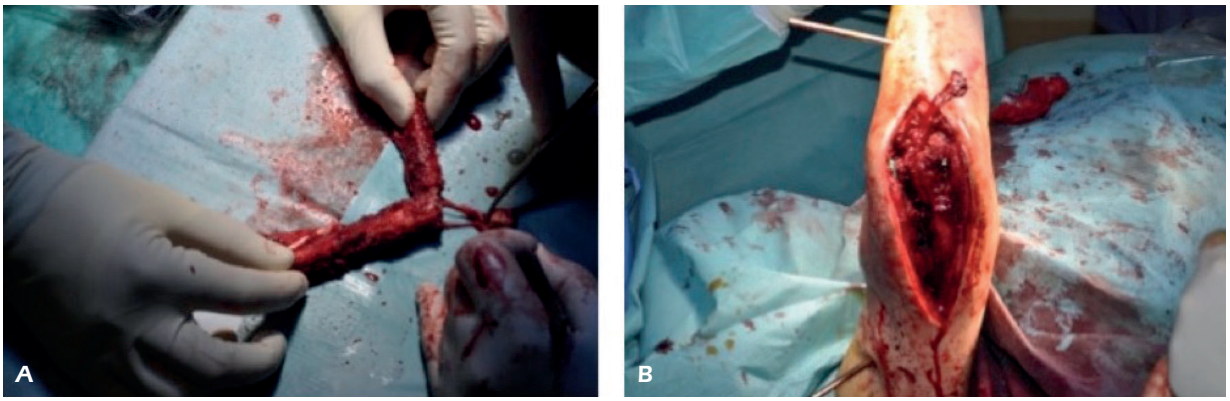


**Figure 4.** Peroneal vascularized bone transfer (**A**), fibular pedicle prepared for reverse radial artery anastomosis (**B**).

During debridement, the lateral condyle and lateral column were preserved. The sclerotic bone of the lateral condyle was perforated by drilling.

The VFG, about 20 cm in length, was harvested from the contralateral leg using the standard technique[13]. The fibula was shaped to obtain two segments in order to reconstruct the trochlear- and medial-column sides, leaving muscle flaps on the articular side. The peroneal bone was vascularized through reverse radial artery end-to-end anastomosis with fibular pedicle and fibular vein anastomosis with the cephalic vein of the forearm. At the contact points between the VFG and the residual humeral bone, we placed free iliac bone crest chips and a collagen membrane (Botiss Biomaterials, Berlin, Germany) soaked with concentrated bone marrow taken from the right iliac crest. The VFG was fixed with two anatomical plates (Acumed, Hillsboro, OR, USA) (Figure 4). The residual medial collateral ligament was fixed on the VFG in anatomic position. Finally, articulated external fixation was applied for temporary immobilization.

### *Follow-up and Outcomes*

One month after final reconstructive surgery, scintigraphic examination showed the vitality of the vascularized fibular graft. The first radiological signs of bone healing were visible three months after surgery, at which time the articulated external fixator was removed. Function and range of motion, as well as radiological signs of bone healing, improved gradually from the third month till one year after surgery (Figure 5). Pain decreased and disappeared by the sixth month of follow-up (Table I). At two years follow-up, the range of motion of the elbow in flexion/extension was 110° to 20°, the Oxford Elbow Score was 43/48 and there was no evidence of infection[14].

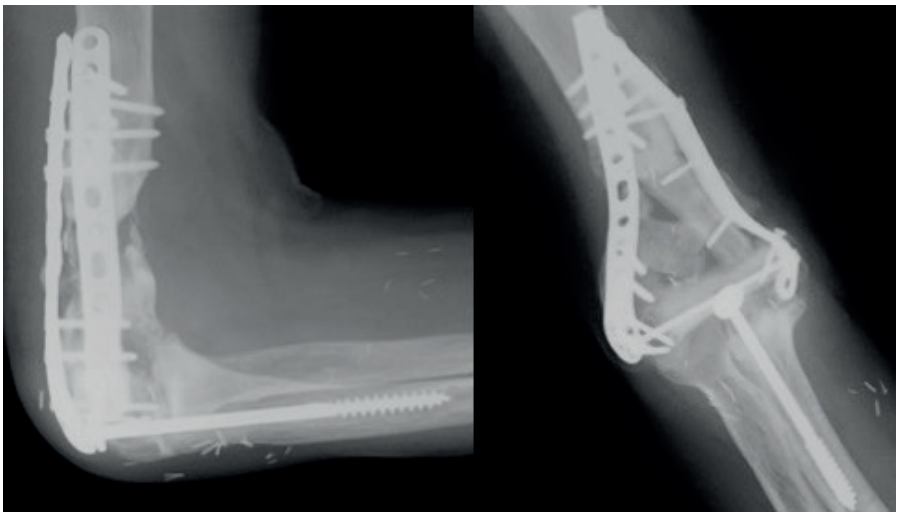

**Figure 5.** Elbow's x-rays at 1 year after reconstructive surgery.

**Table I.** Summary of published cases of nonunion of the Distal Part of the Humerus treated with fibular vascularized bone graft. ROM indicates range of motion; MVA indicates motor vehicle accident; HET indicates high-energy trauma; EL indicates elbow arthrolysis[5,10,19-22].

| Case | Author | Year | Sex | Age | Cause | Articular recosturtion | Infection | Complications | Final ROM Ext/Flex | Clinical outcomes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ring et al | 2003 | M | 31 | -- | no | No | No | 30°/90° | Fair |
| 2 | | | F | 42 | -- | no | No | Loss of alignement/ secondary EL | 35°/135° | Good |
| 3 | Beredjiklian et al | 2005 | -- | -- | Fall | no | No | No | 20°/120° | -- |
| 4 | | | -- | -- | Fall | no | Yes | No | 10°/120° | -- |
| 5 | Adani et al | 2008 | M | 62 | MVA | no | No | No | Full | Excellent |
| 6 | | | M | 30 | MVA | no | No | No | 20°/105° | Excellent |
| 7 | | | M | 21 | MVA | no | Yes | No | 5°/100° | Excellent |
| 8 | | | M | 28 | MVA | no | Yes | Fibular Graf Failure | Arthrodesis | Fair |
| 9 | | | F | 53 | MVA | no | Yes | No | 20°/110° | Good |
| 10 | Cavadas et al | 2010 | M | 29 | HET | yes | No | No | 0/80° | Good |
| 11 | | | M | 32 | HET | yes | Yes | Secondary EL reqiured | 30°/100° | Good |
| 12 | Kerfant et al | 2012 | F | 60 | ? | no | No | No | ? | Good |
| 13 | Zafra et al | 2015 | M | 39 | MVA | yes | Yes | No | 35°/105° | Excellent |
| 14 | Bigoni et al | 2019 | M | 58 | MVA | yes | Yes | No | 20°/110° | Excellent |

## Discussion

Surgical treatment of fractures of the distal humerus can be complex and time-consuming depending on the fracture pattern and degree of comminution, which themselves constrain choices of implants and fixation methods. The patient reported in this paper initially received appropriate surgical treatment but subsequently developed plate failure and delayed union, which lead to infection and non-union accompanied by extensive bone loss.

The frequency of occurrence of non-union in distal humerus fracture surgical repairs ranges from 2% to 10% of all cases; moreover, post-surgical recovery is frequently accompanied by unstable elbows, restricted movement, and attendant functional limitations, as well as significant pain[4]. The planning of surgical repair of a distal humeral non-union with massive bone loss necessitates especially thorough evaluation of (i) the injury pattern, (ii) bone loss and remaining bone quality, (iii) previous surgical treatment, as well as (iv) the patient's overall health.

Limited options include (i) total elbow arthroplasty, (ii) arthrodesis, (iii) elbow interposition arthroplasty, and (iv) fixation with grafting. Nonetheless, there is no currently accepted gold standard of treatment[5,15], especially in those cases of articular damage.

A factor which significantly confounds choice of treatment paradigm is the patient's expectation of renewed joint mobility and its consequent impact of their intended life-style. For example, some patients require only minimal joint mobility (the minority of cases) and consequently have low expectations of treatment on their life-style. For these patients, a total elbow arthroplasty may be a viable and acceptable option. In these patients, a stable fixation of a distal humeral non-union might constitute an unduly difficult and unnecessary option.

By contrast, the majority of patients require a restoration of joint mobility as completely as possible; consequently, some form of reconstructive surgery must be considered[15]. For example, elbow interposition arthroplasty has been reported as a viable option for elbow arthritis in young patients instead of joint replacement[16,17].

In cases where the bone defect is smaller than 5-6 cm, and there is a sufficient quantity of proximal well-vascularized soft tissue, a non-vascularized bone graft constitutes a good treatment option[10]. A bioactive synthetic graft as bioglass[18,19] or calcium phosphate composites[20,21] should be considered but more specific research about humeral septic non-union are required.

By comparison, VFG represents a more viable alternative in the presence of large bone defects of the humerus. This procedure, first described in 1975, was used for the treatment of osteomyelitis, consequent to bone tumor resection and subsequent non-union[22]. Only a few cases of distal humerus non-union treated with VFG have been described (Table I). Ring et al[23] described two non-articular non-unions with large bone loss treated with VFG. In one patient, revision surgery with cancellous bone grafting, including a new plate, was required; thereafter, resultant elbow stiffness was treated with an arthrolysis. Beredjiklian et al[24] described five non-articular distal humeral non-unions with an average segmental bone loss of 3.2 cm treated with vascular bone grafts. Two of these patients, one with a septic non-union, were treated with VFG and no complications were reported. Adani et al[10] treated five non-unions of the distal humerus without articular involvement with VFG and reported three septic non-unions. Bone union was obtained within a mean of 6 months while a second VFG from the other leg was required in only one patient with a large bone gap. Kerfant et al[25] also reported a case of distal humerus aseptic non-union treated with a double-barrel fibular flap and a ''T-shaped'' plate. Cavadas et al[5] described an intriguing surgical technique using vascularized bone transfer for large bone losses of the distal humerus including articular damage. They reported 5 patients aged from 22 to 40 years old (mean age 32 years) with a mean follow-up of 22 months. Their sources of vascularized bone included the iliac crest in three patients, and the fibula in two patients. Results were good with a mean active range of motion of 88°. Recently, interposition arthroplasty using VFG was reported in another case of septic articular non-union of the distal humerus with a good follow-up examination at 20 months[26].

In our case, we modified the previously described technique by preserving the lateral humeral condyle and restoring the trochlear bone, medial column and part of the diaphyseal humerus with VFG. The double elbow anatomic plating guaranteed stability to the construct and the external fixation restored a safe range of motion. Oxford Elbow Score and range of motion progressively increased up to six months and reached good results. Our patient's satisfaction

was achieved at 6 months and was still strong at 2 years follow-up. Consequently, the quality of treatment and patient quality of life meets those previously achieved by other techniques.

Reconstruction of bone defects of the distal humerus with VFG should be considered an efficient and reliable technique for specific cases resulting in very good outcomes. This technique is particularly useful in situations of large bone loss or an infection that could limit the use of other treatments which appear to have higher rates of complications.

### Disclosure of interest

The authors declare that they have no competing interest.

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